Air Quality Forecasting, Mapping, and Monitoring
Communicating Air Quality
March 15-18, 2010
Raleigh Marriott City Center, Raleigh, NC

AIR QUALITY FORECASTING OVER ITALY FOR THE WEB SERVICE LAMIAARIA.IT

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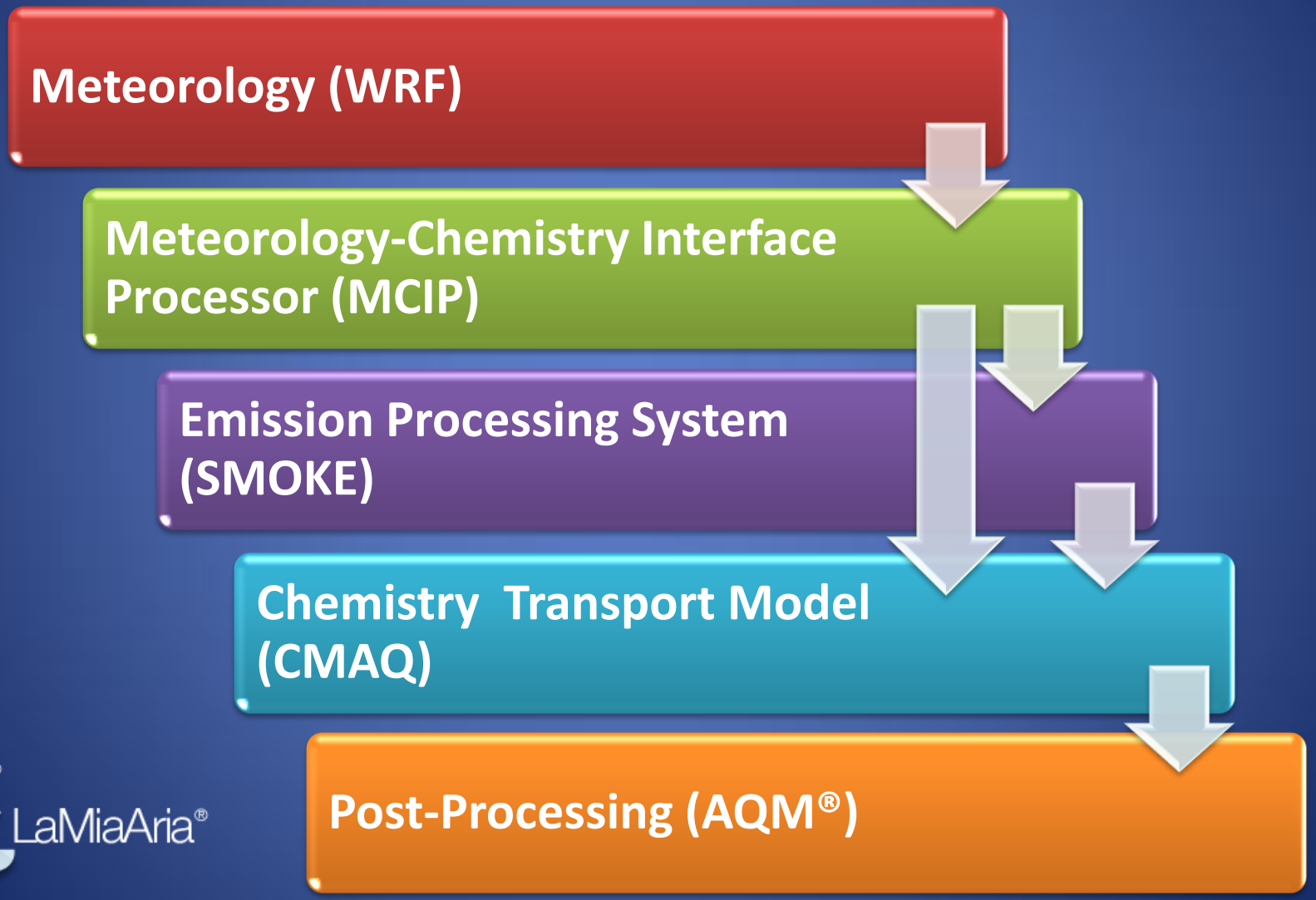
Outline

- LaMiaAria modeling system
- Nested domains
- Model configurations
- The Dust model
- Emissions
- Results and case studies
- Future work

LaMiaAria Modeling System Structure



LaMiaAria®

LaMiaAria MODELING SYSTEM DESCRIPTION

Meteorological driver	Weather Research and Forecasting (WRF)
Chemistry	Gas- and heterogeneous- phase chemistry using Carbon Bond IV (CB-IV) mechanism (CB-V mechanism in test system)
PM representation	• sectional approach, 2 emissions bins (fine/coarse) • 3 modal log-normal size distribution for transport and deposition • Advection, diffusion and dry & wet deposition
Emissions	Different methodology and data sources for the different scales
Domain specifics	• 54 km grid covering Europe and North Africa • 18 km grid covering central Europe • 6 km grid covering Italy

LaMiaAria®

Nested Domains

Domain	Coverage	Spatial resolution
Domain1	Europe + North Africa	54 km (77 X 111)
Domain2	intermediate	18 km (84 X 78)
Domain3	Italy	6 km (177 X 213)

CMAQ CONFIGURATION

Current operational CMAQ forecast still uses static profile lateral boundary condition (LBC).

The initial conditions (IC) for CMAQ are set from the previous forecast cycle.

ADOPTED SCHEMES:

- Yamartino global mass-conserving scheme to calculate horizontal and vertical advection
- diffusion coefficient based on local wind deformation
- calculate vertical diffusion using the Asymmetric Convective Model version 2
- deactivate plume in grid model
- 2nd generation CMAQ aerosol deposition velocity routine
- RADM-based cloud processor that uses the asymmetric convective model to compute convective mixing
- Aerosol module : the 3rd generation modal CMAQ aerosol model (AERO 3/AERO5)

WRF CONFIGURATION

Nested Domains

D54	80 x 114
D18	94 x 91
D6	193 x 216

Vertical Layers

27 sigma pressure

ADOPTED SCHEMES:

- NCEP/GFS data
- No grid analysis nudging
- No observation nudging
- Reisner mixed phase
- Kain-fritsch cumulus parameterization (54 and 18 km grid)
- YSU PBL scheme (Hong and Noh)
- Shortwave atmospheric radiation scheme: CLOUD (Dudhia)
- Longwave atmospheric radiation scheme: RRTM
- Shallow convective scheme
- Multi-layer soil model
- Surface layer model : Monin-Obukhov similarity theory

THE DUST MODEL

The algorithm used to assess surface dust flux is based on the Dust Entrainment and Deposition model (DEAD, Zender, 2002). The flux of dust, expressed in Kg/m^2s, released in the atmosphere and then transported by CMAQ (in 2 bins fine/coarse fractioned following D'Almeida [1987] size distribution) is given by:

$$F = \alpha\, Q(u_*, u_{*t}) \cdot A_m \cdot T \cdot S$$

S	Erodibility factor (to reveal Hot Spots)	[Ginoux, 2001]
T	Tunable Factor	
A_m	Bare soil fraction	[Zender, 2003]
$\alpha = f(\text{soil texture}) = 100\exp[(13.4\, M_{clay} - 6.0)\ln 10]$		Mobility Efficiency
$Q = Q(u_*, u_{*t}) = \text{const} \cdot u_{*t}^3 [1 - (u_{*t}/u_*)^2] [1 + u_{*t}/u_*]$		Horizontal Flux
$u_* = (\tau/\rho)^{1/2}$		Friction Velocity
$u_{*t} = f(D, Re_{*t}, \rho_p) \cdot F_c$	Threshold Friction Velocity	[Iversen & White, 1982]

54 and 18 km GRID EMISSIONS

For the 54 and 18 km grid, the contributions of the anthropogenic sources (road transport, non road transport, industry, agricultural sources, etc.) are implemented using the last available version of:

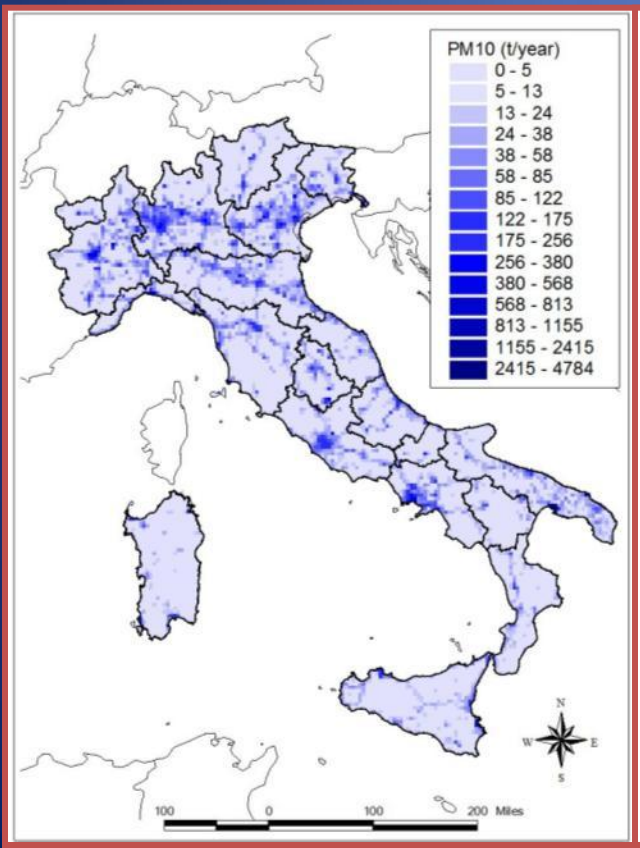
- European Monitoring and Evaluation Programme (**EMEP**) emission database;
- Emission Database for Global Atmospheric Research (**EDGAR**), excluded particulate matter, for north African areas;
- European Pollutant Emission Register (**EPER**) for industrial point sources.

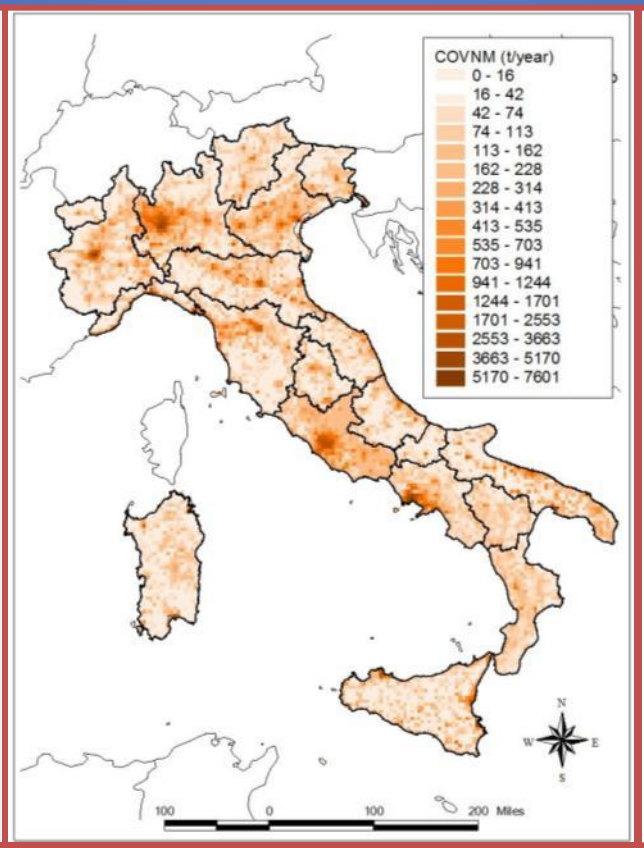
The spatial disaggregation is evaluated according to the methodology of the surrogate variables, using geographic data in a GIS platform (primary traffic, CORINE land cover by European Environment Agency) related to the emissions sources.

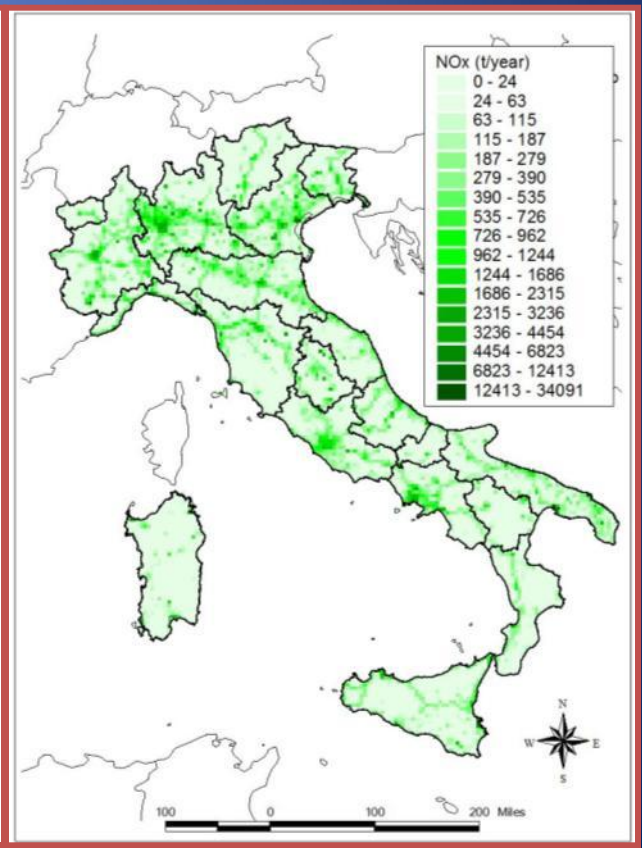
6km GRID EMISSIONS

The inventory of emissions for the Italian national territory (6 km grid) is carried out using the National Emission Inventory provided by the Institute for Environmental Protection and Research (ISPRA), according to the CORINAIR classification

The municipal spatial disaggregation is carried out from the emissive data on a provincial base according to the methodology of the proxy (or surrogate) variables.



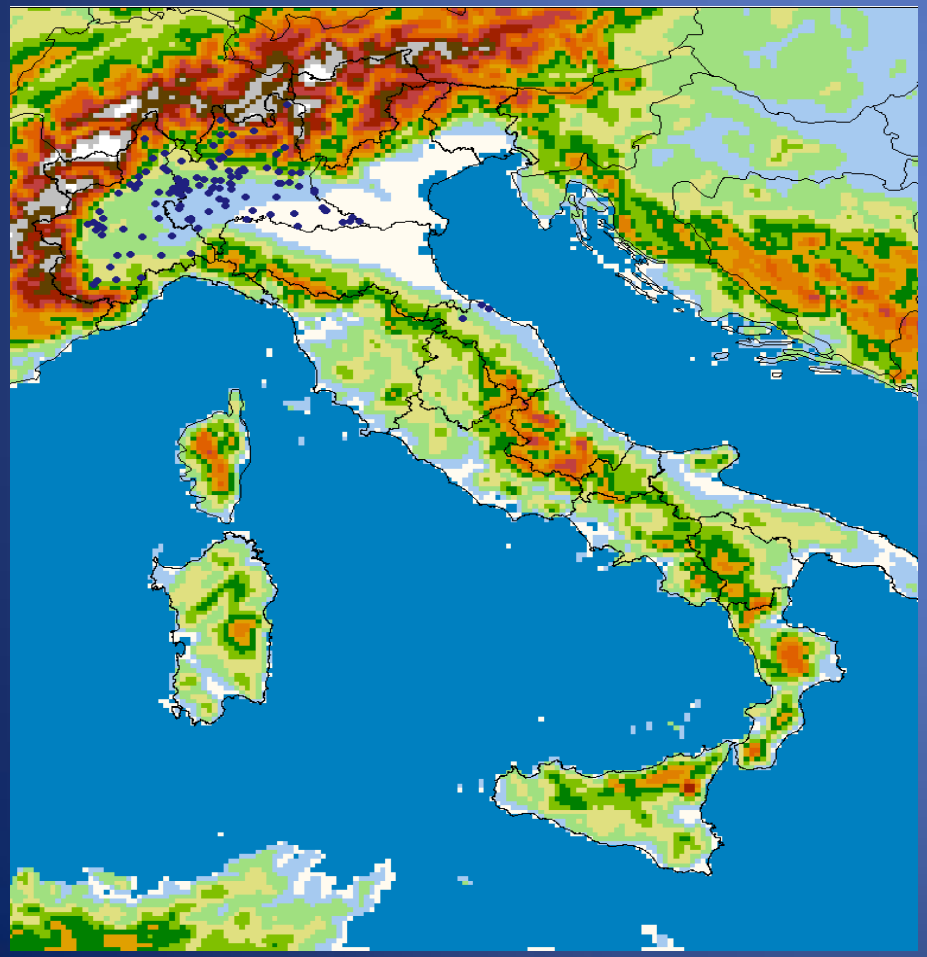




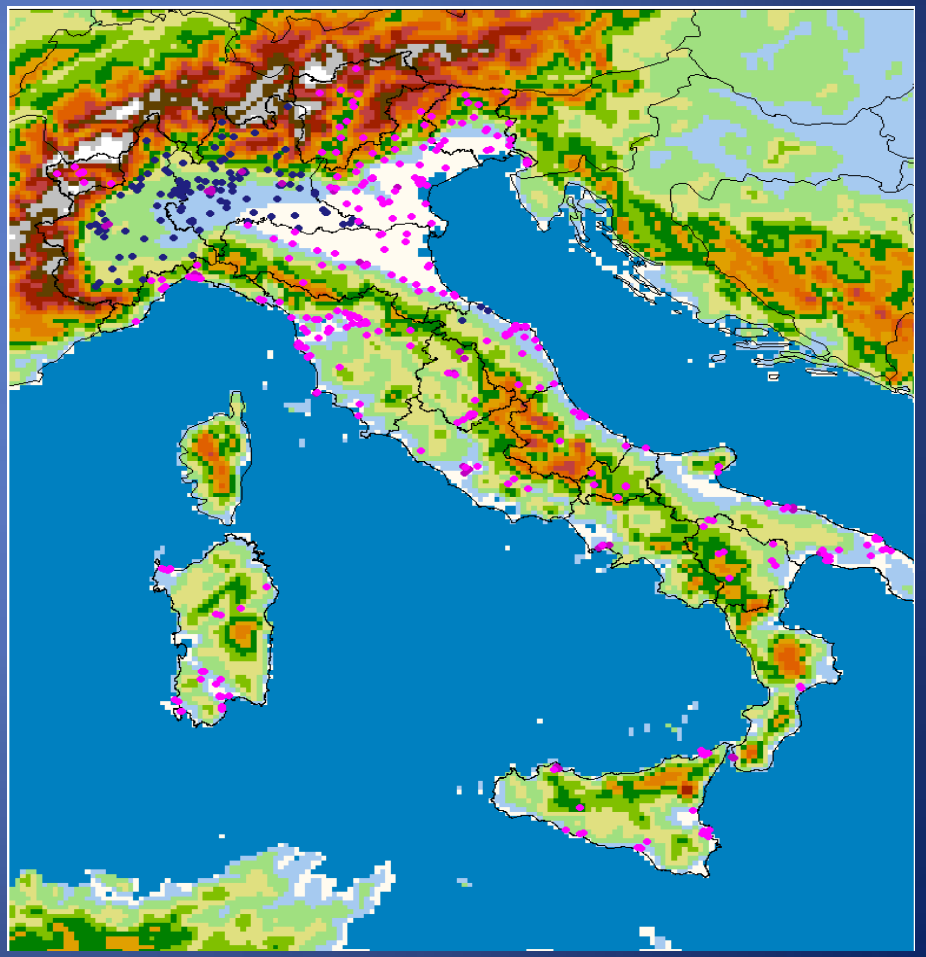
Model validation and calibration

AQM® AirMatch is the system module daily intercomparing model predictions with the publicly available data from the official regional EPA (ARPA) monitoring networks

hourly means
136 monitoring station

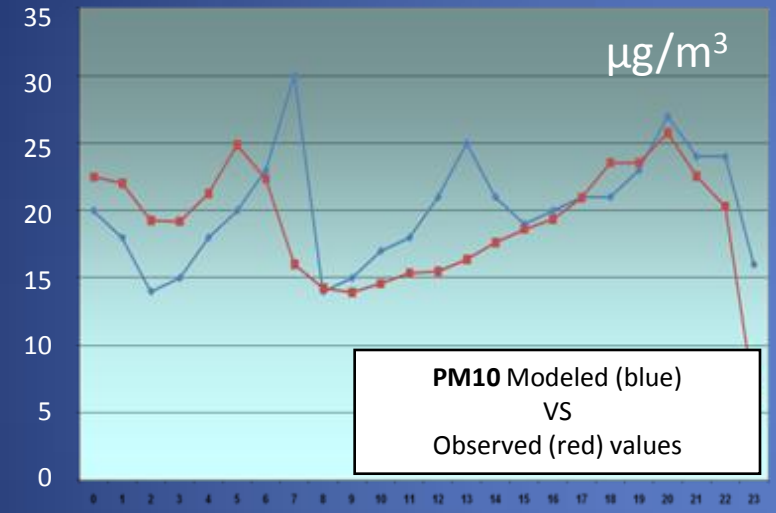


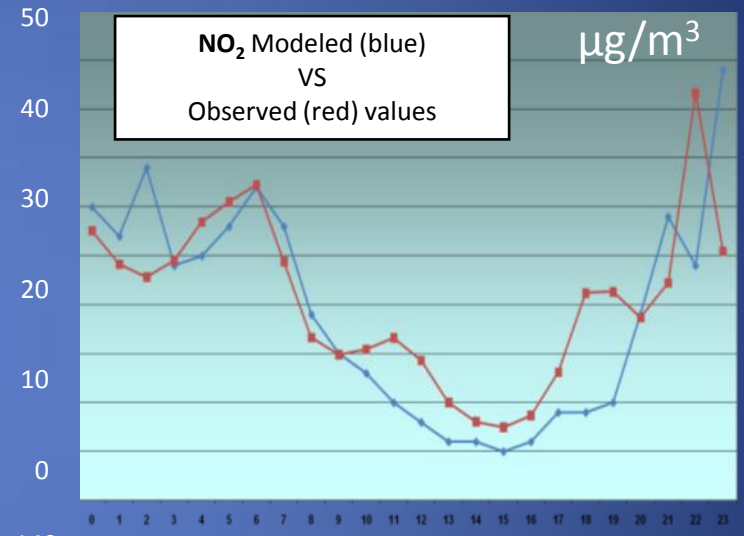
daily means
391 monitoring station

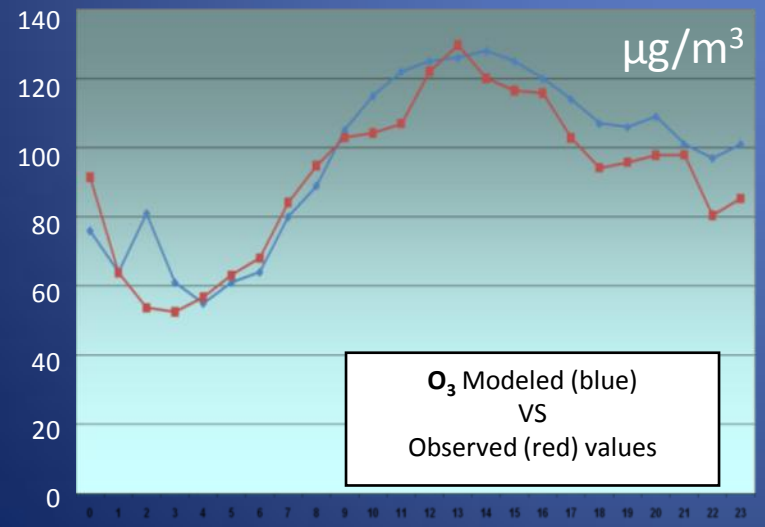


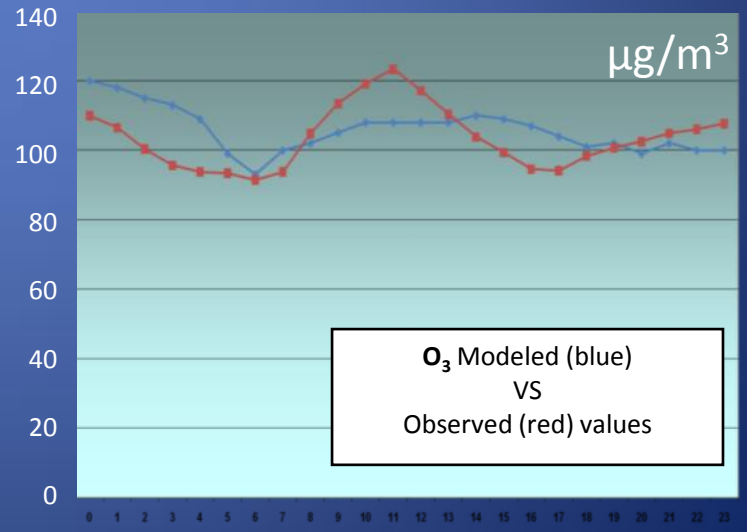
some hourly matching

Ponzone (Al, 14 May 2009) for PM10, Cremona (15 June 2009) for NO2, Alessandria (20 June 2009) and Acqui Terme (8 May 2009) for O3.

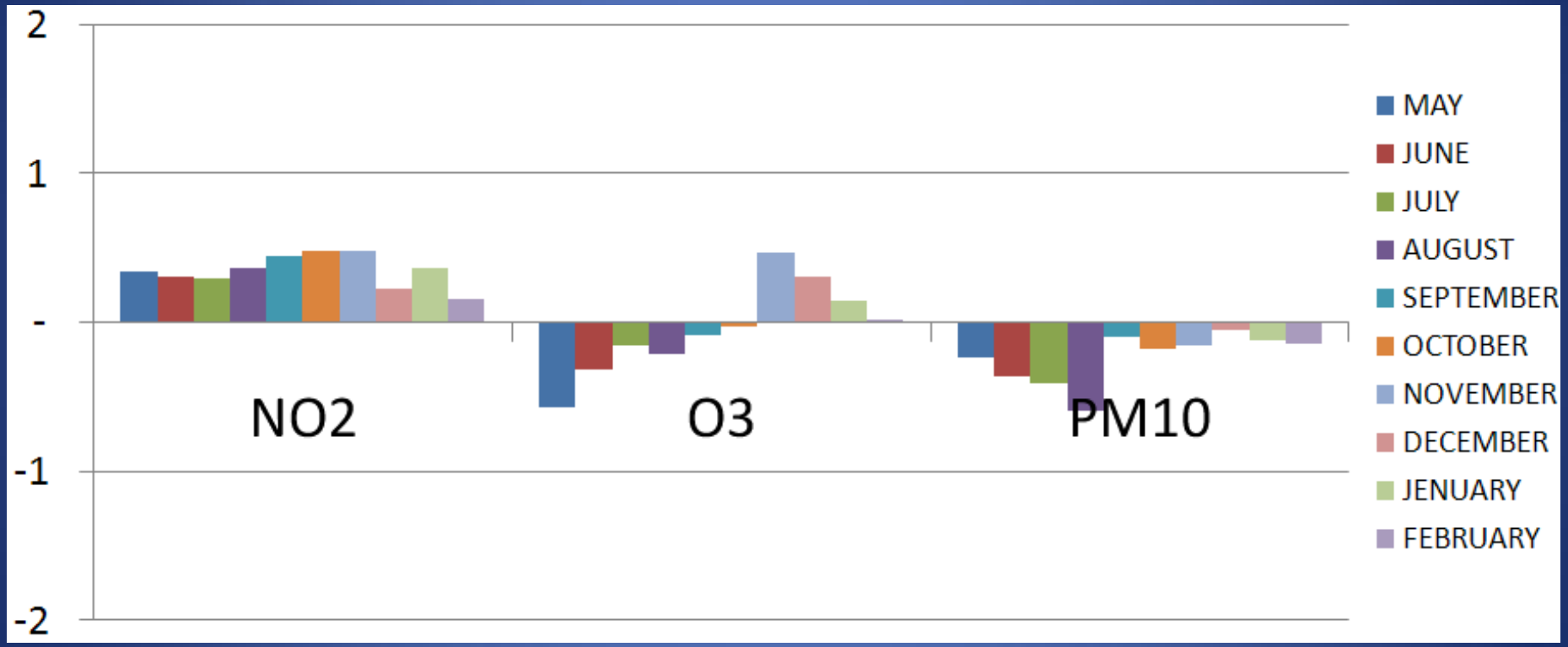








Model validation: Fractional Bias



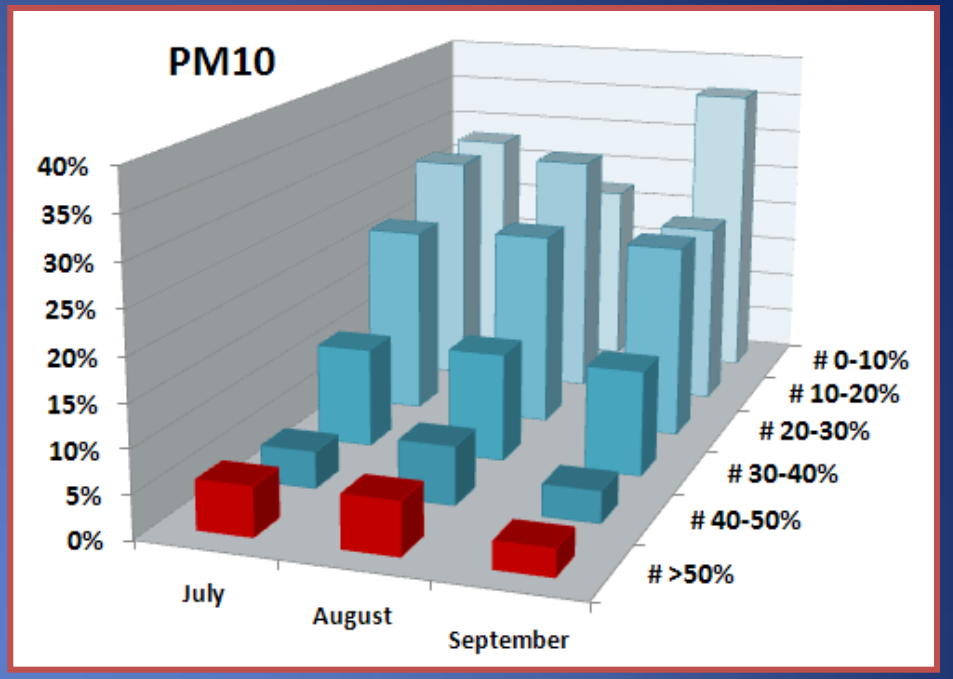
(114 stations) **(83 stations)** **(53 stations)**

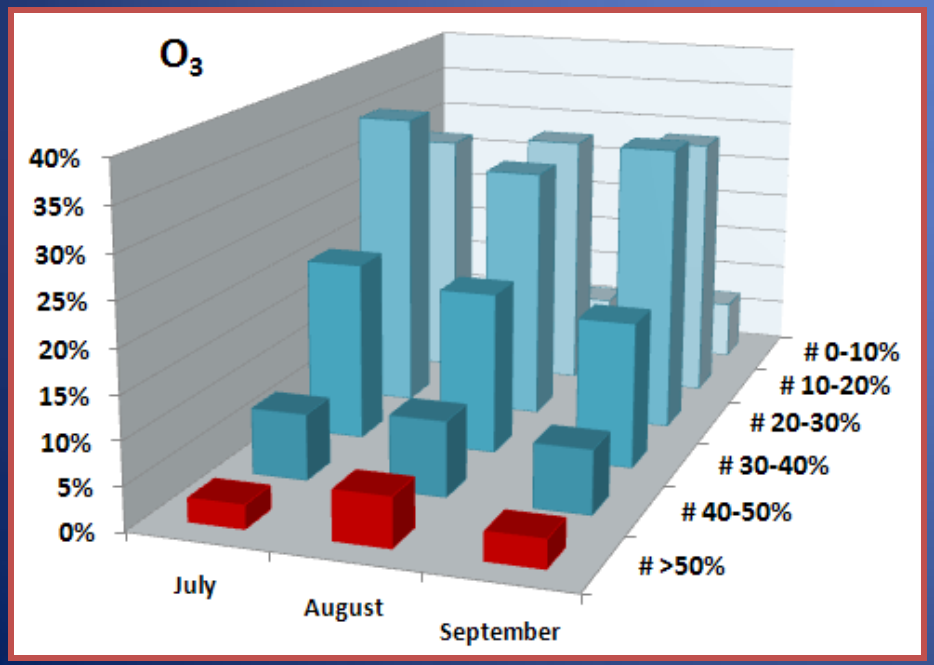
Results

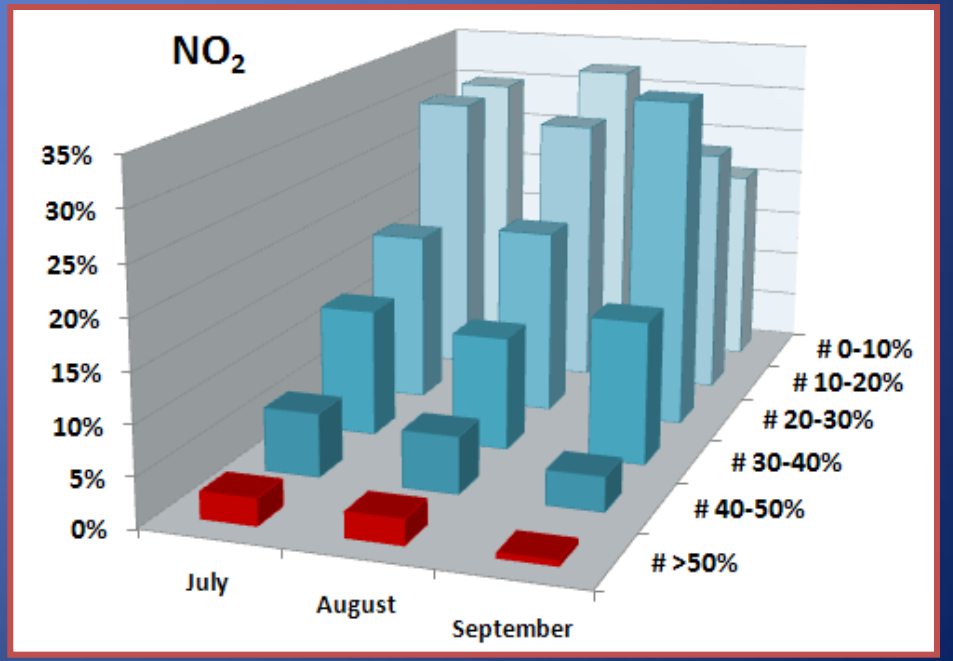
European directive for modeling uncertainty

$$EVA = 100\,\frac{MAX\,(C_{pred} - C_{obs})}{LM}$$

LM: European AQ Stadard (Target value for O3)
EVA with values exceeding the regulatory target (50%) depicted in red





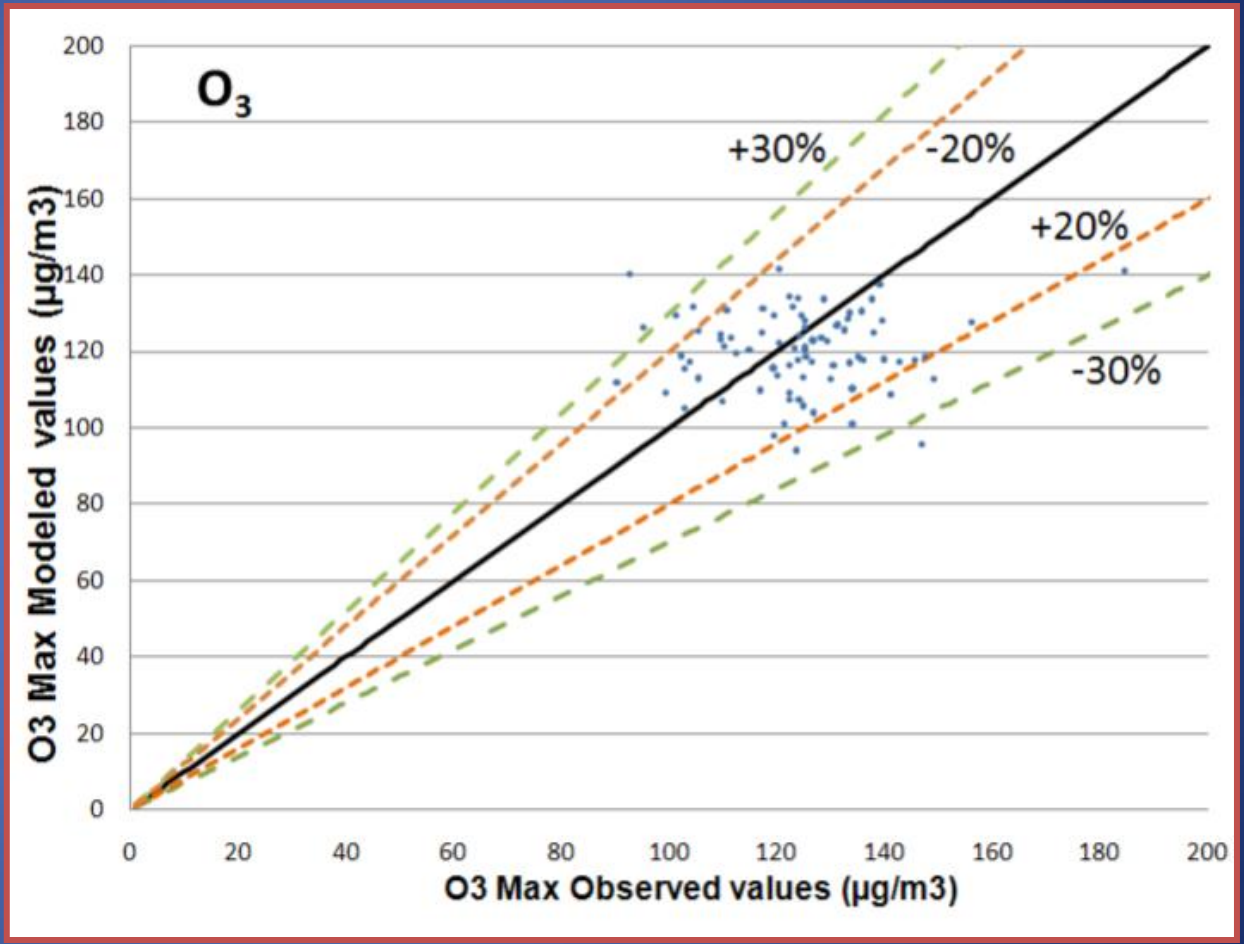


Summer Ozone results

24-h Max for O_3 in 83 stations.

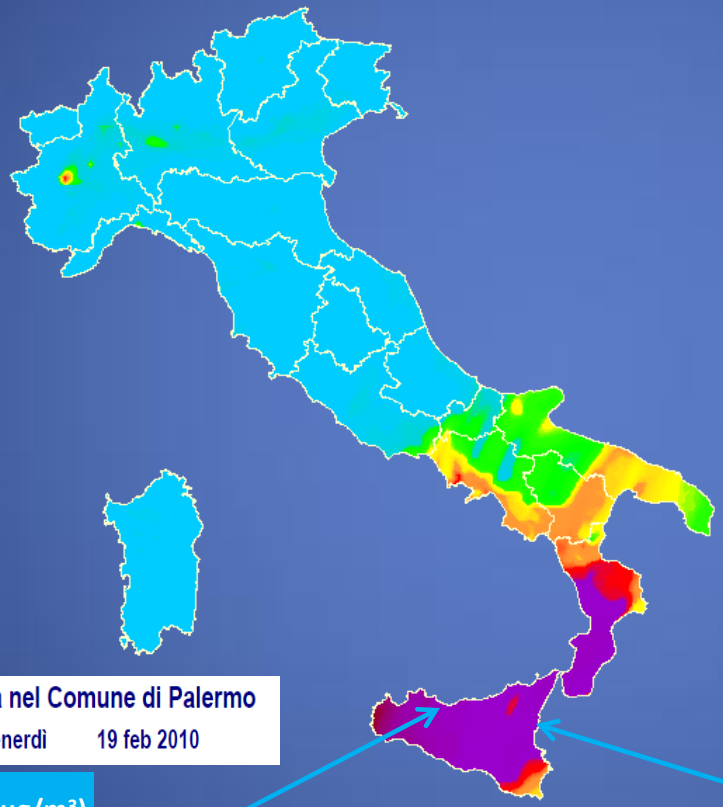
Analyzed Period:
July 1st 2009
September 30th 2009

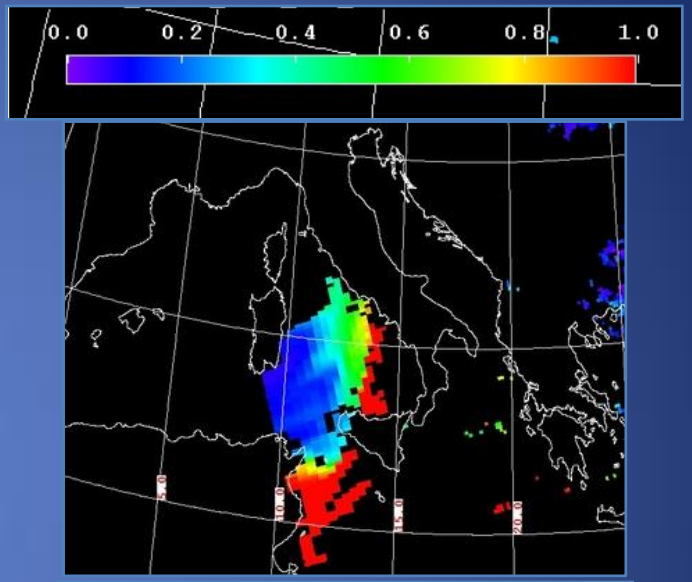
Summer O_3 daily-max modeled values are 96.4% inside the range ±30%
and 86.7% inside ±20%



02/19/2010: Saharan Dust Outbreak

PM10 (µg/m³) | 0-25 | 25-50 | 51-62,5 | 62,5-75 | 75-87,5 | 87,5-250 | >250





h 11.00 AM, MODIS AOD

Rilevamento della qualità dell'aria nel Comune di Palermo

Sintesi dei dati validi rilevati: venerdì 19 feb 2010

Station	PM10 (µg/m³)
Boccadifalco	92
Indipendenza	133
Giulio Cesare	153
Castelnuovo	143
Torrelunga	136
Belgio	129

Comune di Catania

Direzione Ecologia e Ambiente

Bollettino giornaliero della qualità dell'aria

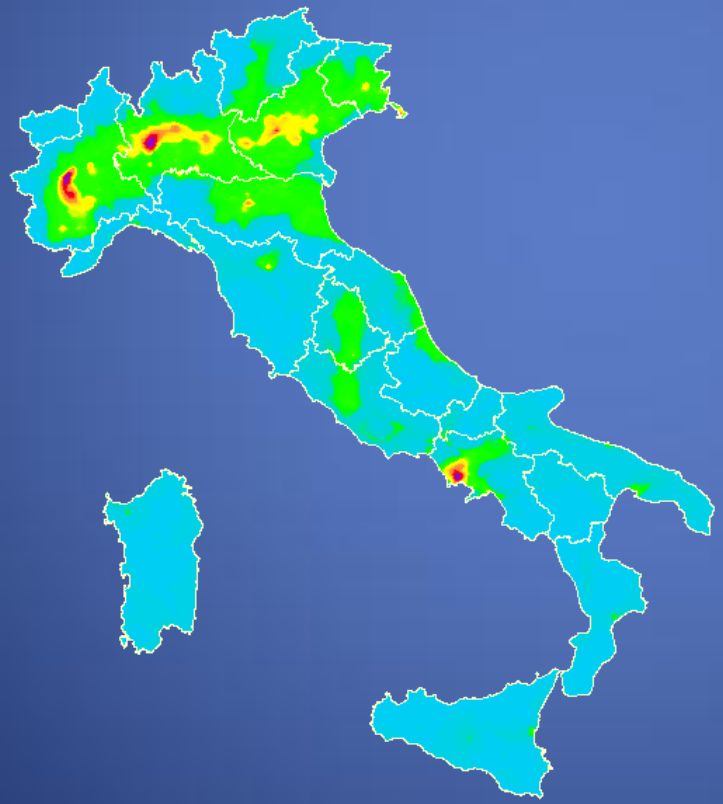
PERIODO DI RIFERIMENTO:DALLE ORE **8** DEL **19/02/10**

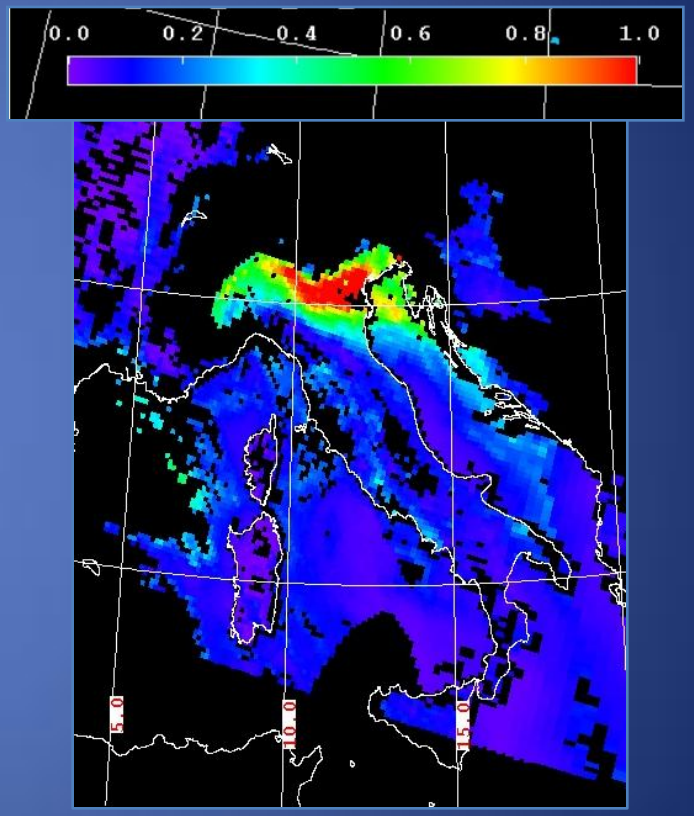
Station	PM10 (µg/m³)
Librino	110
P.za A.Moro	136
Viale V.Veneto	119
P.za Stesicoro	139

02/28/2009: Industrial and traffic air pollution event in Po Valley

PM10 (µg/m³)

0-25	25-50	51-62,5	62,5-75	75-87,5	87,5-250	>250





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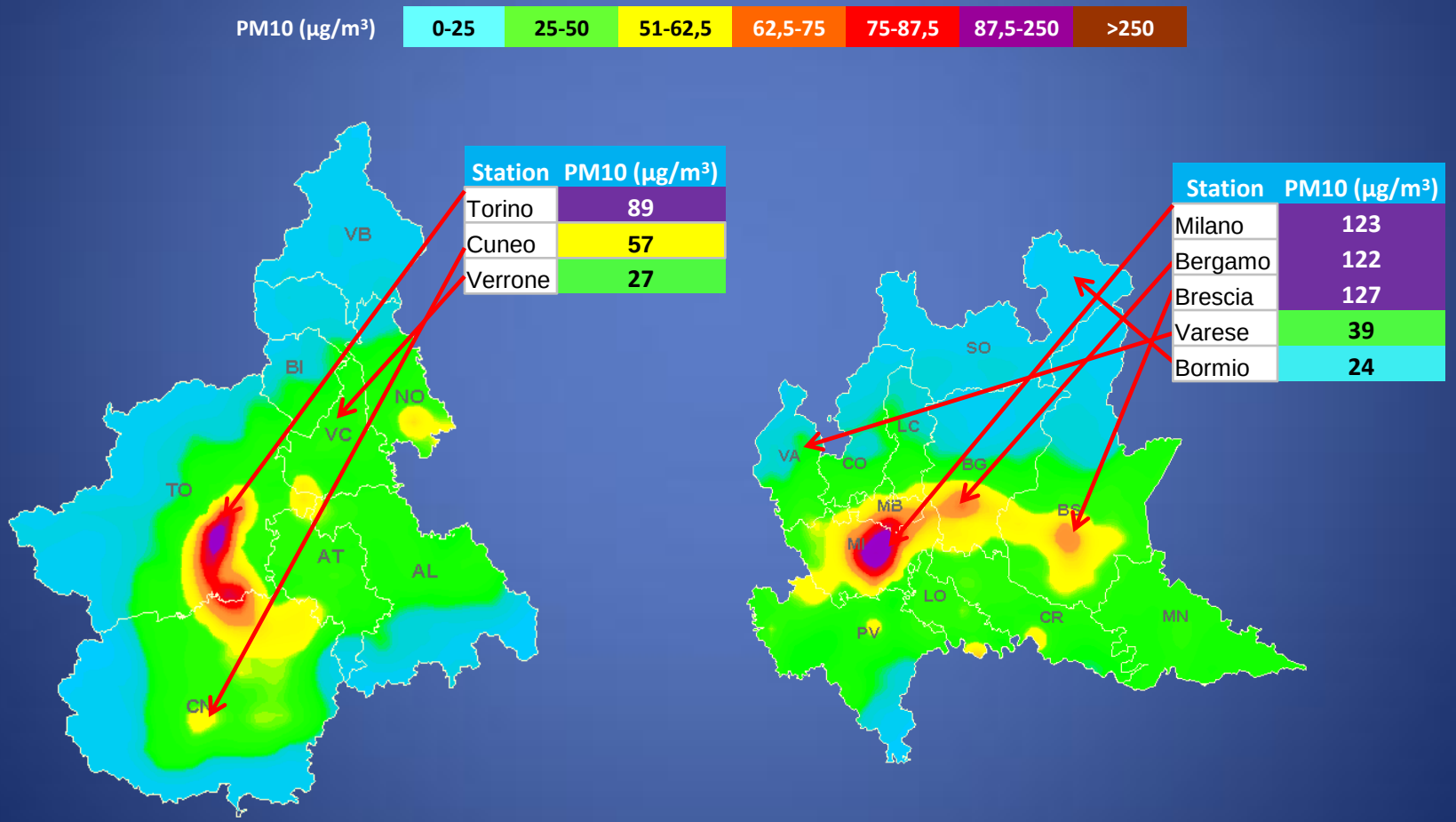
02/28/2009: Industrial and traffic air pollution event in Piemonte and Lombardia region



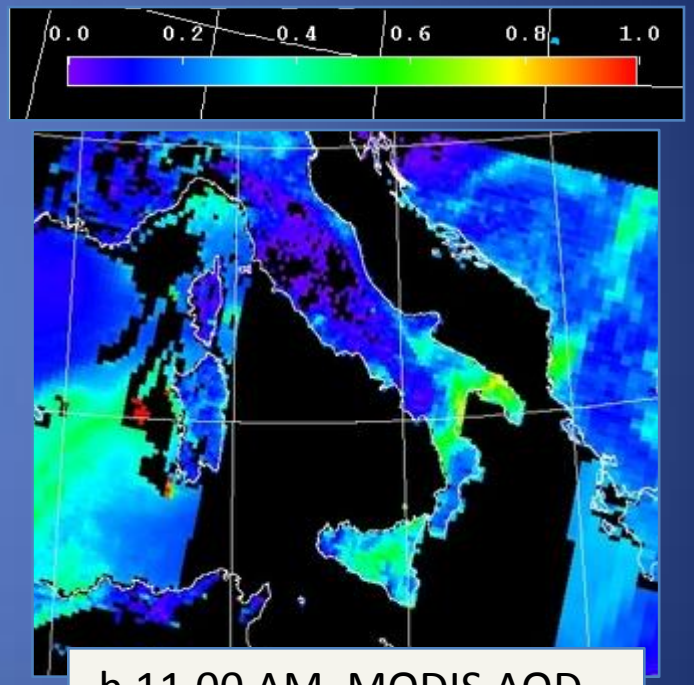
Station	PM10 (µg/m³)
Torino	89
Cuneo	57
Verrone	27

Station	PM10 (µg/m³)
Milano	123
Bergamo	122
Brescia	127
Varese	39
Bormio	24

07/24/2009: Industrial plants in Puglia

PM10 (µg/m³) | 0-25 | 25-50 | 51-62,5 | 62,5-75 | 75-87,5 | 87,5-250 | >250

Station	PM10 (µg/m³)
Statte	52
Casa Circondariale	52
Paolo VI	66
Via Archimede	48
Via Machiavelli	54



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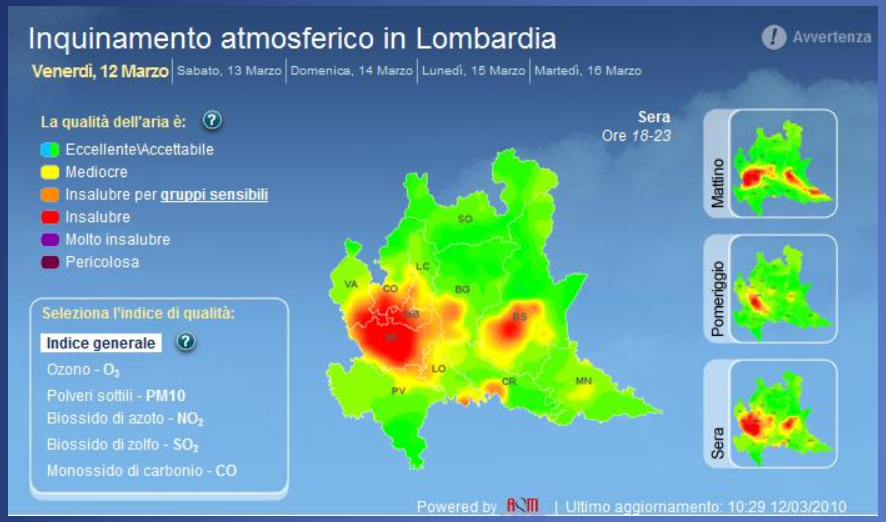
LaMiaAria web site: www.lamiaaria.it

Region maps


Inquinamento atmosferico in Lombardia
Avvertenza
Venerdì, 12 Marzo | Sabato, 13 Marzo | Domenica, 14 Marzo | Lunedì, 15 Marzo | Martedì, 16 Marzo
La qualità dell'aria è:
Eccellente\Accettabile
Mediocre
Insalubre per gruppi sensibili
Insalubre
Molto insalubre
Pericolosa
Seleziona l'indice di qualità:
Indice generale
Ozono - O3
Polveri sottili - PM10
Biossido di azoto - NO2
Biossido di zolfo - SO2
Monossido di carbonio - CO
Sera
Ore 18-23
Mattino
Pomeriggio
Sera
SO
LC
VA
CO
BG
MB
BS
MI
LO
CR
MN
PV
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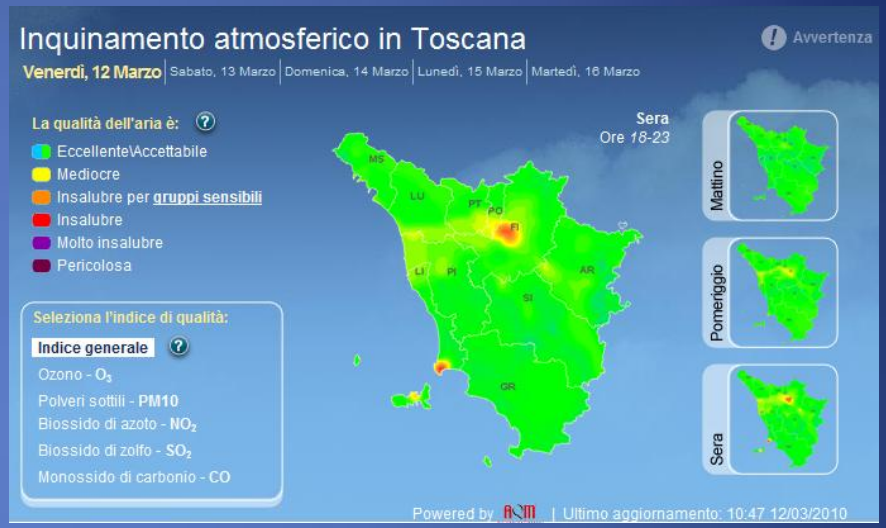
Inquinamento atmosferico in Toscana
Avvertenza
Venerdì, 12 Marzo | Sabato, 13 Marzo | Domenica, 14 Marzo | Lunedì, 15 Marzo | Martedì, 16 Marzo
La qualità dell'aria è:
Eccellente\Accettabile
Mediocre
Insalubre per gruppi sensibili
Insalubre
Molto insalubre
Pericolosa
Seleziona l'indice di qualità:
Indice generale
Ozono - O3
Polveri sottili - PM10
Biossido di azoto - NO2
Biossido di zolfo - SO2
Monossido di carbonio - CO
Sera
Ore 18-23
Mattino
Pomeriggio
Sera
MS
LU
PT
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FI
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GR
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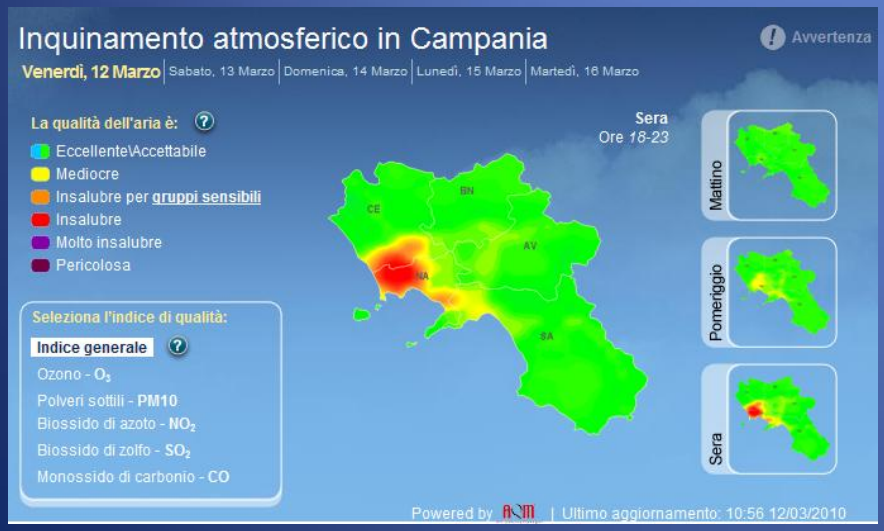
Inquinamento atmosferico in Campania
Avvertenza
Venerdì, 12 Marzo | Sabato, 13 Marzo | Domenica, 14 Marzo | Lunedì, 15 Marzo | Martedì, 16 Marzo
La qualità dell'aria è:
Eccellente\Accettabile
Mediocre
Insalubre per gruppi sensibili
Insalubre
Molto insalubre
Pericolosa
Seleziona l'indice di qualità:
Indice generale
Ozono - O3
Polveri sottili - PM10
Biossido di azoto - NO2
Biossido di zolfo - SO2
Monossido di carbonio - CO
Sera
Ore 18-23
Mattino
Pomeriggio
Sera
CE
BN
AV
NA
SA
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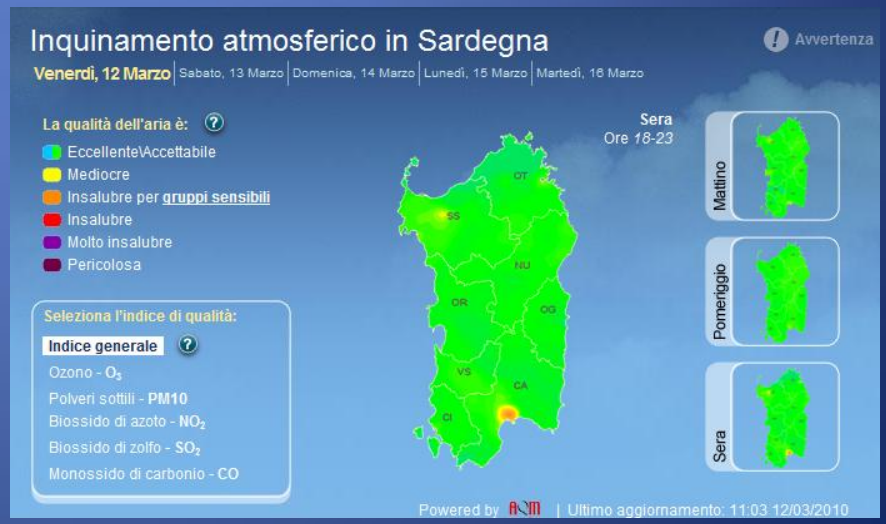
Inquinamento atmosferico in Sardegna
Avvertenza
Venerdì, 12 Marzo | Sabato, 13 Marzo | Domenica, 14 Marzo | Lunedì, 15 Marzo | Martedì, 16 Marzo
La qualità dell'aria è:
Eccellente\Accettabile
Mediocre
Insalubre per gruppi sensibili
Insalubre
Molto insalubre
Pericolosa
Seleziona l'indice di qualità:
Indice generale
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Biossido di zolfo - SO2
Monossido di carbonio - CO
Sera
Ore 18-23
Mattino
Pomeriggio
Sera
OT
SS
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CI
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Future works

Short-term

* Global CTM BC: INCA model
* Postprocessing, i.e., bias correction (e.g., KF-based algorithm)

Medium-term:

* Probabilistic prediction system based on ensemble data assimilation

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Thank you for your attention

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